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14. ABSTRACT This report results from a contract tasking CITEFA (Scientific and Technical Institute of the Armed Forces) as follows: The contractor will investigate a viable maintenance process to address delamination of aged integral fuel tank coatings that will provide appropriate long term corrosion protection to the interior surfaces of the integral fuel tanks. The contractor will also deliver a prototype sensor capable of detecting the onset of integral fuel tank corrosion through either or both ionic and/or biological means.					
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Final Report- Corrosion Research Department- CITEFA- Argentina

ELECTROCHEMICAL DEVICE FOR DIAGNOSIS AND CONTROL OF CORROSION RISKS IN INTEGRAL FUEL TANKS

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ABSTRACT

The tester described in this report allows instantaneous indication of the presence of separate water at the bottom of liquid fuel tanks and of the amount of contaminant salt, acids or microbial contaminants it contains. It thus provides a fast and easy technique for alerting on the corrosion risks of fuel tanks due to the aggressiveness of accumulated water.

INTRODUCTION

A very well known problem is the development of biological sludge in wing tanks (1-8) and ground deposits (9) when turbo fuel is in contact with underlying water.

Some of the problems reported, associated to settled water and microbial growth in wing tanks of aircraft, are:

- Clogging of the filters of turbines
- Malfunction of pumps and fuel level indicators
- Deterioration of the interior coatings of the tanks
- Reduction in the quality of the fuel.
- Corrosion of the alloy conforming the lower kin of the wings
- Stress corrosion cracking susceptibility of the AA 2024 T351 alloy (15,16).

One prototype of this device was in service during 2 years in a Hercules C 130 aircraft of the Argentine Air Force, showing a satisfactory performance in the prevention of those failures, through microbial proliferation inhibition (10).

This instrument, **Detector H₂O-X-MP**, was designed to provide fast and easy indication of corrosion risk. Initially it was developed to advise the presence of settled water (H₂O) in integral fuel tanks. The aggressiveness of water due to its salt or acid content (X) and the magnitude of microbial proliferation (MP) are also measured. Its application to ground fuel deposit focus on the same problem complementing the security measures to avoid jet fuel

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contamination in Military Air Bases, where this type of problem is most frequently reported. Automatic drainage can be programmed for each positive detection thus preventing the risk of bottom corrosion from inside and subsequent perforation of ground deposits.

DESCRIPTION

The **Detector H₂O-X-MP** device consists of a set of two-electrode sensor (one for each tank to be controlled) and an electronic command instrument.

The sensor is formed by two concentric metallic electrodes, separated by an insulator material, between which an electric current circulates when a given potential difference is applied with the command instrument. According to the research work performed special constructive characteristics and materials are used to make the mentioned current, proportional to the concentration of corrosive contaminants in the water and to the amount of microbial proliferation in the tank **(11-16)**. It is fixed in the deposit bottom where the water accumulates due to room temperature decrease in the bulk tank.

Portable versions are developed for discontinuous checking of fuel tanks. Only the remote sensor should be fixed at the bottom in each fuel tank.

The command instrument is always out of the tank:

- in the cockpit, in aircraft,
- in a console, in service stations, Military Air Bases and other installations requiring a regular control,
- a portable model can be used through connection to the terminals of sensors installed in ground deposits.

It commands the remote sensing of the presence of water, the concentration of corrosive components content and the amount of microbial proliferation occurred in a tank.

A microprocessor allows to optionally program the frequency of controls, command an alarm or start a pump which manual or automatically drains the water once detected, regardless its contamination level. A previous record of the result allows the follow up the origin of the water detected and thus to solve the problem, which caused its presence in the tank.

The control of distinct tanks can be done through the remote electric switch of channels of the instrument, in a fixed installation, or by means of a portable equipment connecting it to the sensors installed in each tank, if a permanent control is not required.

The portable model is useful for the control of numerous tanks when a fixed installation is not available. That is the case of distant tank non-requiring a frequent control. The only fixed element, which should be placed in the lower point of the tank, is the sensor. It is connected to the command unit to test each tank. Only one instrument can be used for as many sensors as tanks are to be checked. If water elimination is desired, a fixed tube up to the bottom of the tank should be installed, fixed to the sensor. The pump to eliminate water once detected should be provided with the instrument for this check up modality.

ADVANTAGES CONCERNING THE PRESENT STATE OF HOUSEKEEPING CONTROL

In Aircraft:

1. No incubation is needed, as in the case of the Microb Monitor Test kit from Boron Oil Co., which requires 48 hours incubation before its change in color indicates the presence of aerobic microbial contaminants.
2. It is not necessary to empty the tank as when visual inspection of the bottom is done. This avoids putting the aircraft or ground deposit out of service.
3. Installed at the bottom of the tank it detects the presence of separate water. If proliferation occurs the instrument indicates its magnitude, lessening infestation and the subsequent need for biocide treatments.
4. It can also be used outside the tank, with the sensor submerged in its drained water, while the fungal mat can be retained inside during the drainage.
5. It can prevent increases in fuel prices.
6. Easy to read. No experience is needed to get the correct answer (the presence of water, any corrosive contamination or microbial proliferation), as when sump water has to be examined for any peculiarity that could suggest microbial proliferation.
7. Easy to install and operate. No design modifications are needed in the aircraft integral fuel tank or ground deposit.
8. It can be used as an independent control or as feedback to any existing aircraft scavenging system.
9. Sumping practices can be reduced to minimum because the presence of water can be physically checked.
10. It can be programmed to automatically command water deviation to the turbines as soon as detected. Previous record of its contamination level allows to follow up the origin of that water and to solve the problem.
11. Its use can avoid human errors during water drainage as well as this time consuming operation prescribed in manuals.
12. Essential in aircraft for the diagnosis of the presence of water when capacitive fuel level indicators are working erratically.

In ground deposits of Military Air Bases:

1. It detects separate water, indicating its aggressiveness level (on the steel unprotected walls) in jet fuel ground deposits. Maintenance cost of deposits can be lowered to the necessary minimum because salt or microbial contamination is actually determined.
2. It allows automatic detection and instantaneous solution of the problem.
3. Automatic drainage can be programmed and adjusted to different risk conditions.
4. It prevents inner corrosion of any liquid fuel tank.
5. The entrance of water from groundwater, river or sea can be detected when perforation occurs by corrosion from the outside, due to aggressiveness of the soil or insufficient external protection to the underground tank.

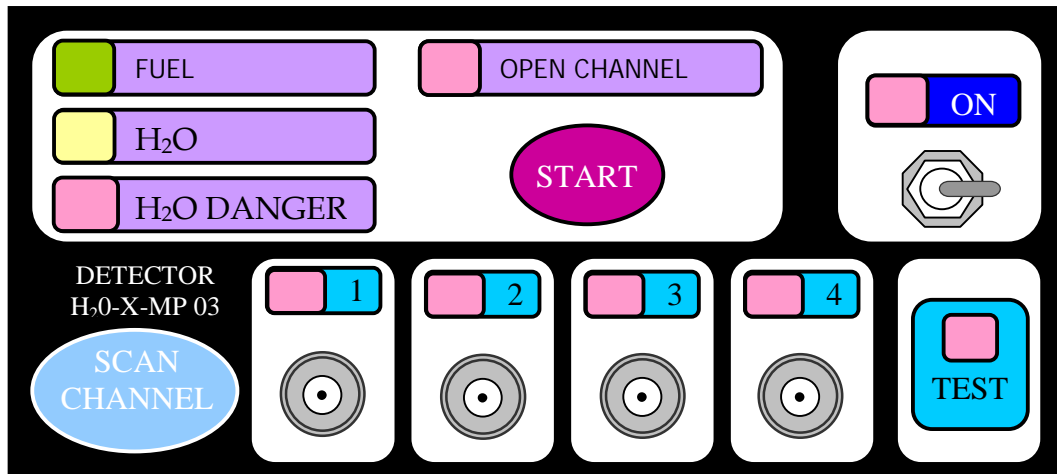


Figure 1. View of the front panel of the "ex - situ" model

Specifications:

- Electronic command: Fixed, 100 x 120 x 180 mm
Portable, 220 x 166 x 120 mm
- Sensor: 50 mm length, 25 mm diameter

Presentation:

- Fixed, 220/110 V or aircraft voltage, 4 or 6 channels
- Portable, 4 channels, rechargeable battery powered

Weight:

- Fixed Command, 1000 g
- Portable, 1400 g

Operation:

The operation of the device is described according to the commands shown in Fig. 1. Once turned "ON", the "SCAN CHANNEL" button commands the self-test of the components through the sequential connection of all the sensors, one by tank, in correspondence with the number of the channels. During this checking "INT" pilot is lit. The "START" button initiates the analysis by the tank (1-4) whose channel number is lit. Selection of the next tank is done by pushing the "SCAN" button. When any discontinuity

occurs in the circuit of a sensor, "OPEN CH" lights up, advising of failure during the test of that particular tank or channel.

The response, on the upper left-hand side of the panel, indicates the presence of "FUEL" or "WATER" in the bottom of the respective tank. The green pilot indicates the absence of water while the amount of contaminants in the tank, "WATER" and "WATER DANGER" is visualised by means of yellow and red lights. These remain alight for 5 seconds, the time for each reading.

Thus, the control of four (4) tanks can be performed in less than one (1) minute.

CONCLUSIONS

The **Detector H₂O - X - MP** is an electronic device, which provides remotely controlled detection of separate water in fuel storage tanks.

- It allows remote detection of corrosive water/jet-fuel contaminants (salts, acids and microbial proliferation), thus advising before corrosion can occur,
- Therefore, cleaning operations can be reduced to the necessary minimum,
- Biocide treatments are unnecessary
- It can be programmable to drain water automatically once detected; then aggressive conditions leading to corrosion cannot be established. Record of each measurement result allows following up possible cause for water presence, as well as its contamination level, detected in the respective fuel tank.

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